Technologies for the First Interstellar Explorer: ***Beyond Propulsion***

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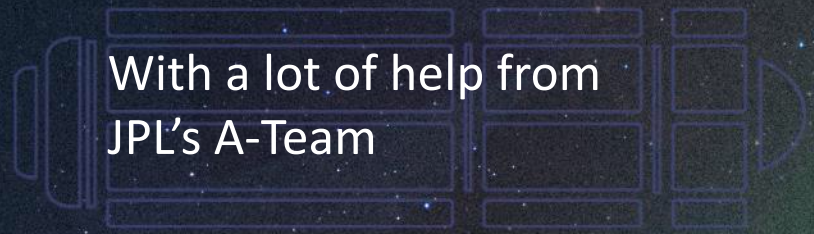


With a lot of help from JPL's A-Team

STARSHIP FUNCTIONS
BY PHASE

MISSION PHASES

I. ACCELERATE OUT OF OUR SOLAR SYSTEM

II. SURVIVE CRUISE TO PROXIMA CENTAURI

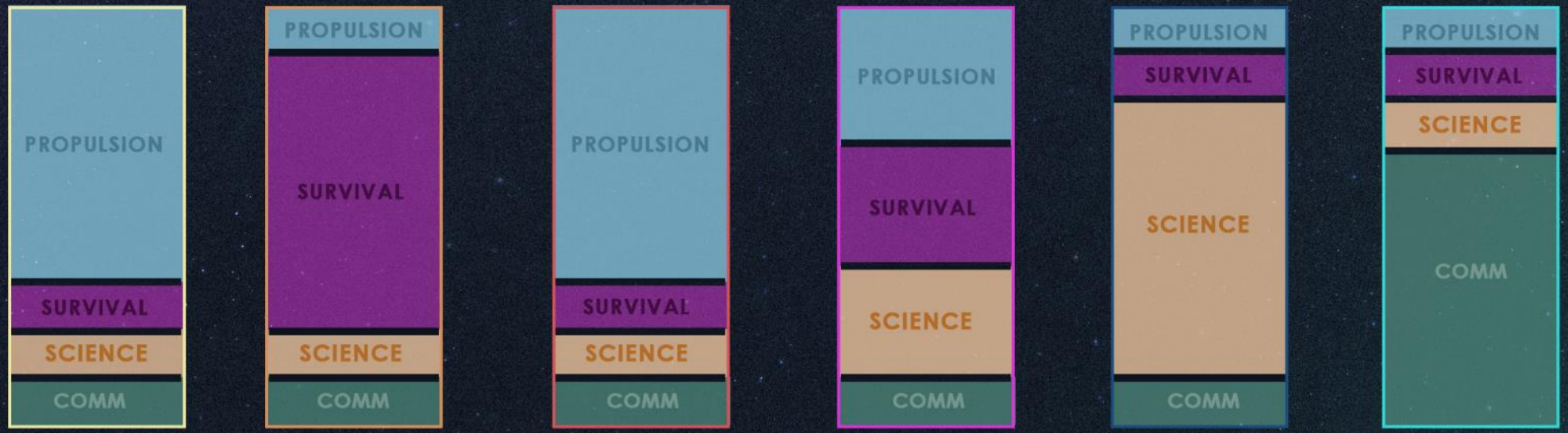
III. DECELERATE ON APPROACH

IV. ADJUST TRAJECTORY FOR CLOSE ENCOUNTER

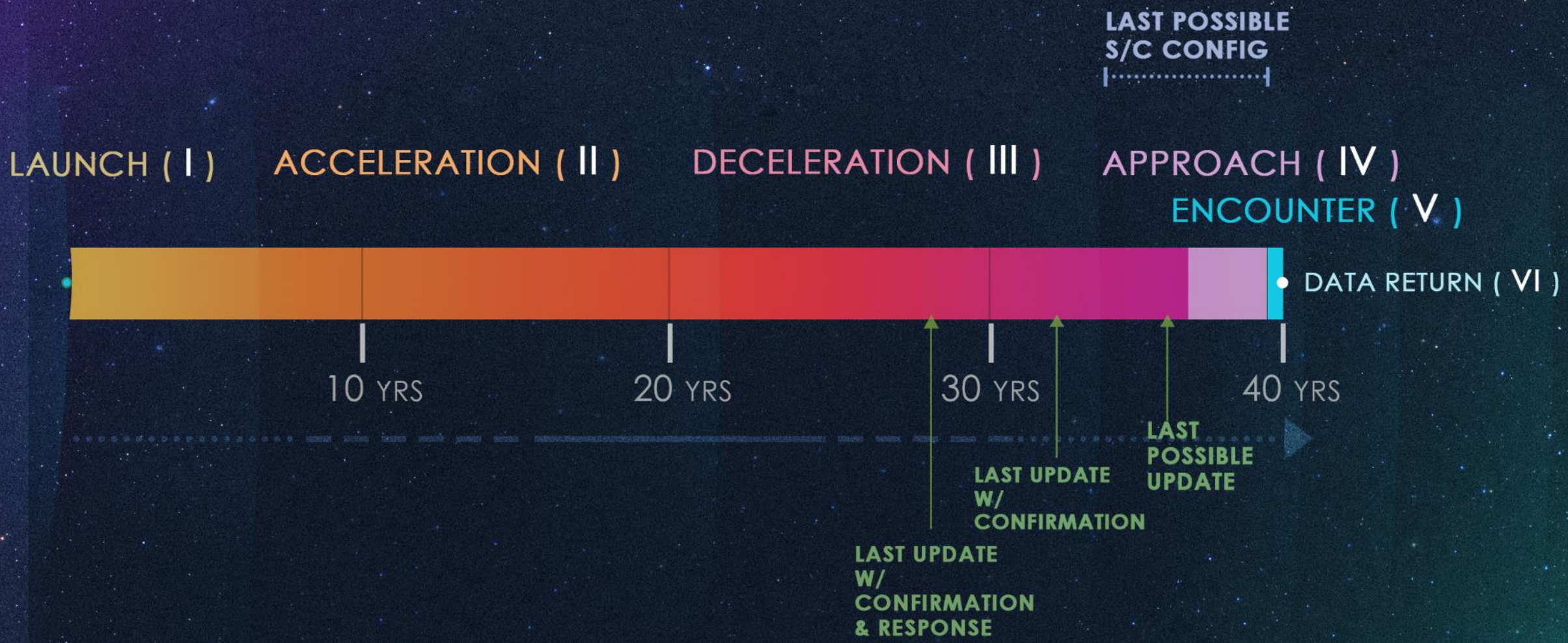
V. AQUIRE SCIENCE DATA

VI. RETURN INFORMATION TO EARTH

FUNCTIONS



PROPULSION
SURVIVAL
SCIENCE
COMMUNICATION



MISSION PHASES AND DECISION POINTS

In the Encounter Phase, our Explorer will essentially be on its own

MISSION OPTIONS

SUPPORT MISSION

PRIMARY MISSION

EARTH SUN

GRAVITY LENS

550 AU

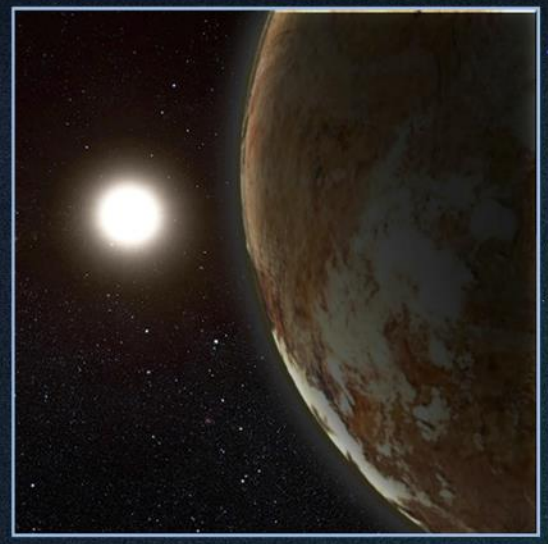
1 AU

270,000 AU

WITH GRAVITY LENSING

1,000 x 1,000 pixels

TODAY



FULL ENCOUNTER

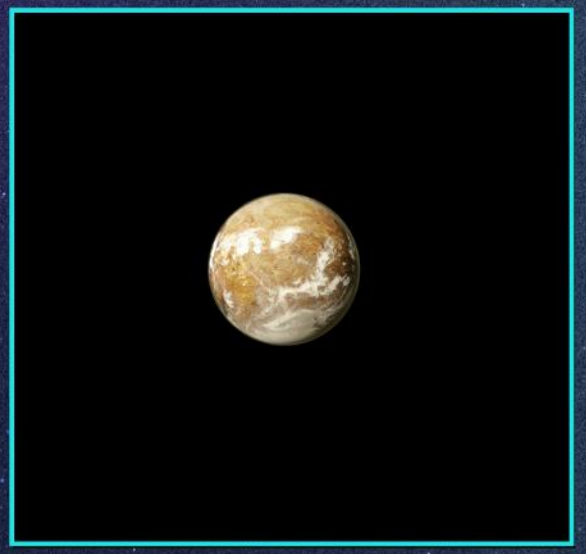
GOAL

Analogy is Hubble and New Horizons @ Pluto

Key Question is: How much do we expect to learn before our Explorer arrives?

MISSION ENCOUNTER
PHASES

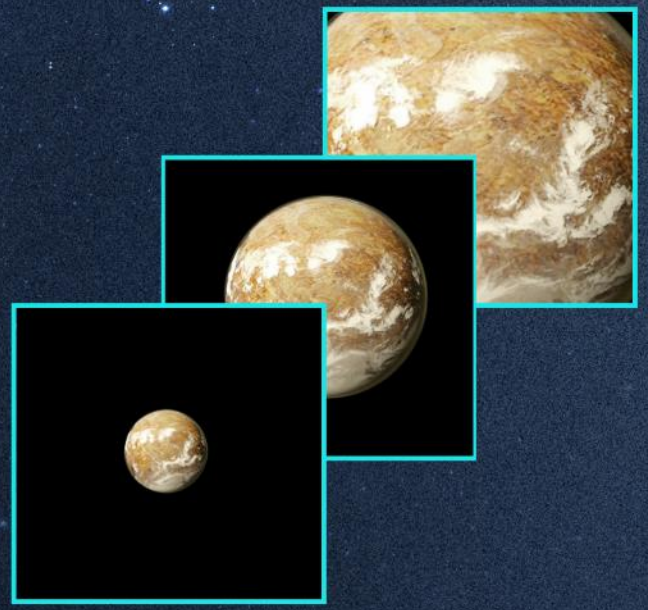
HIGH



MINUTES

NO BRAKING
PASS BY ***0.1-0.2 LIGHT SPEED***

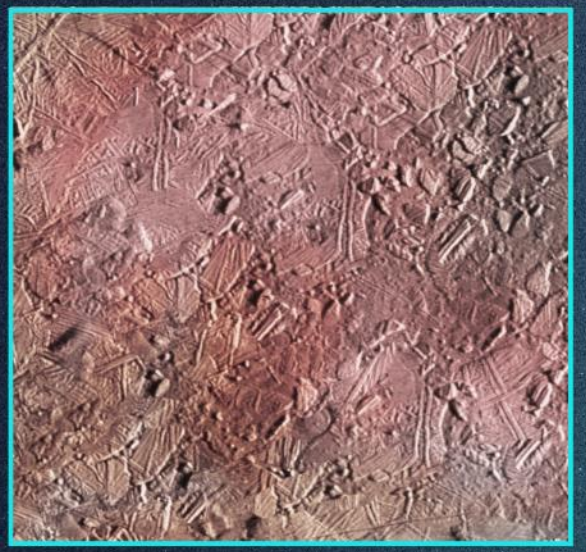
MEDIUM



HOURS

SLOW DOWN
LIKE ***NEW HORIZONS***

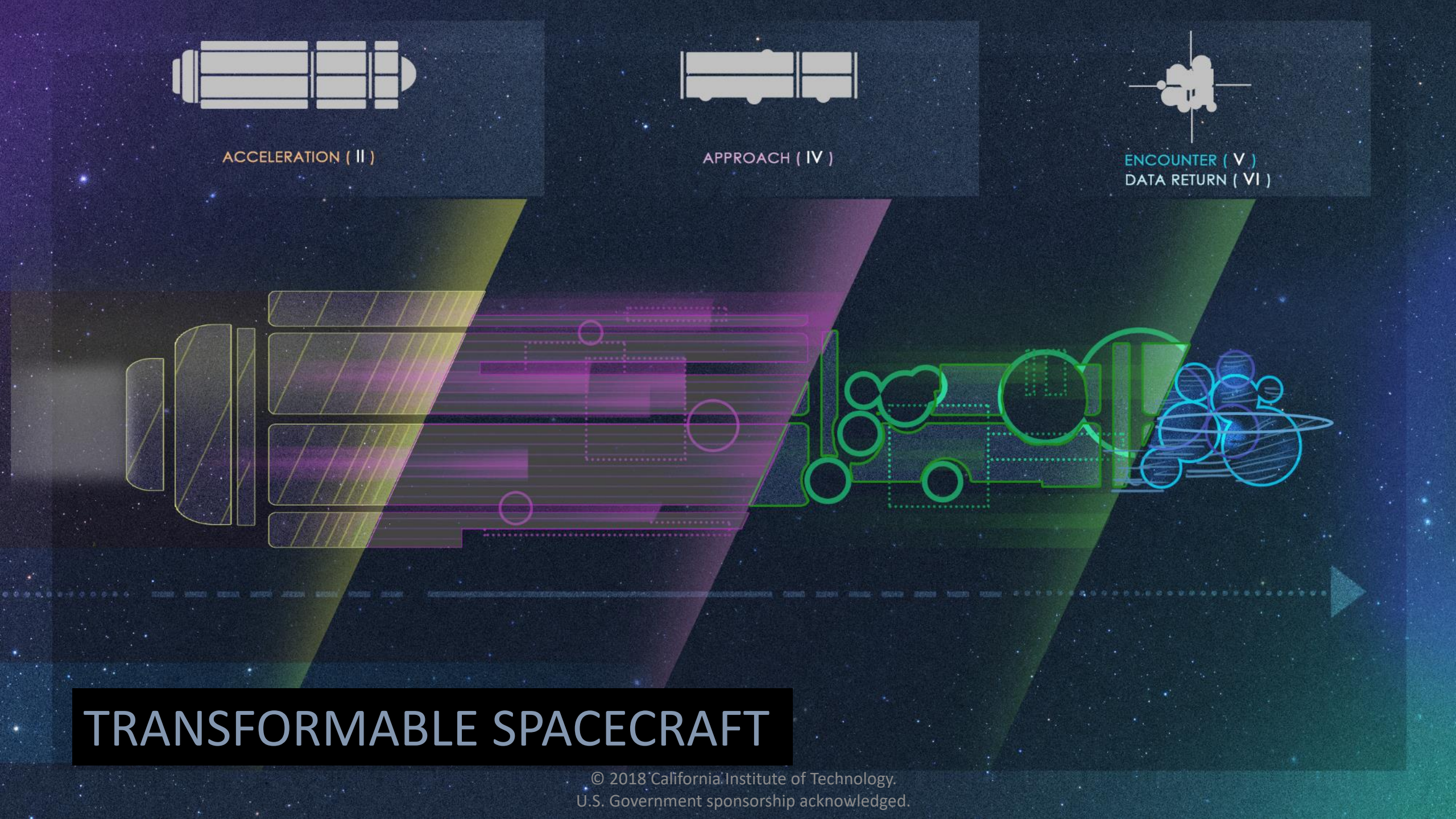
LOW



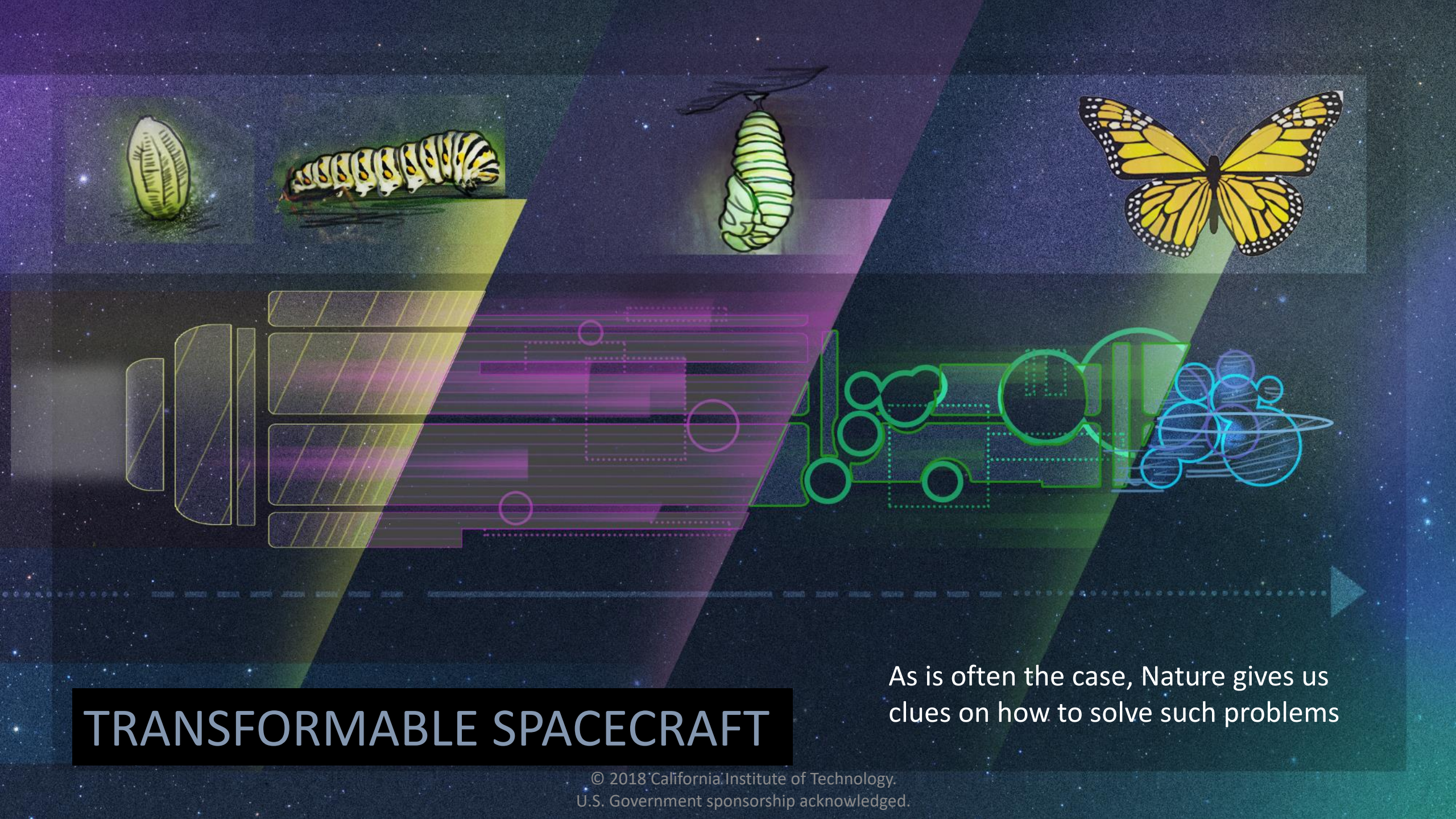
YEARS

ENTER ORBIT
LONG TERM

Science Value increases
as Relative Velocity slows



TRANSFORMABLE SPACECRAFT



TRANSFORMABLE SPACECRAFT

As is often the case, Nature gives us clues on how to solve such problems

SUPPORT MISSION

EARTH SUN

PRIMARY MISSION

GRAVITY LENS

550 AU

270,000 AU

DATA RETURN

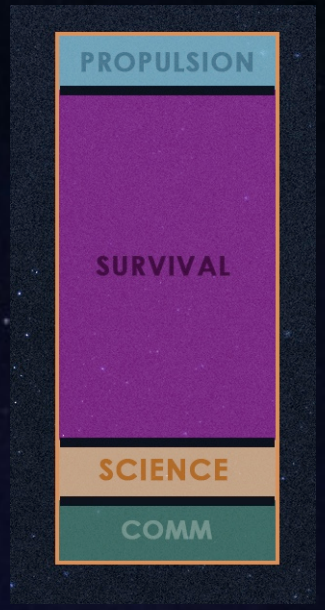
OPTICAL COMM* ENHANCED BY GRAVITATIONAL LENSING?

MORE CONVENTIONAL RF? ~~QUANTUM ENTANGLEMENT?~~

*as suggested by John Brophy (A-Team)

Voyager I left our solar system in 2012

MISSION FUNCTIONS



Voyager I
Launched in 1977 (40 years ago!)
Current Speed 17 km/s
140 AU from the Sun

Downlink telemetry 16 bits/sec
Uplink telemetry 160 bits/sec
Onboard Computer Memory 70 kBytes

Power available 249 W
Flight Software: FORTRAN/C

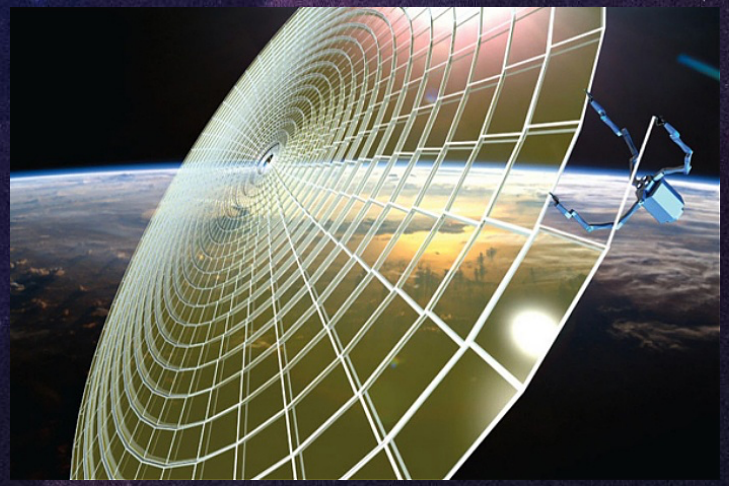
Imagine if we could upgrade Voyager to present-day technology levels?

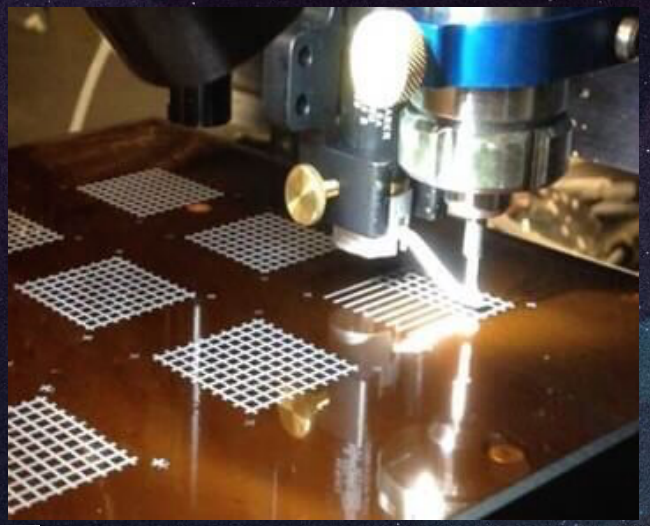
voyager.jpl.nasa.gov

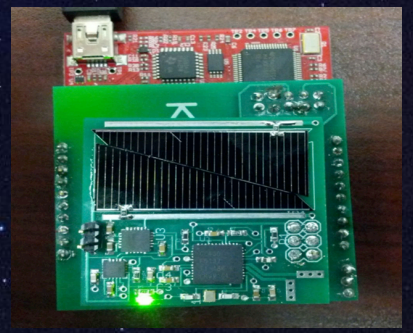
JPL-CALTECH/NASA

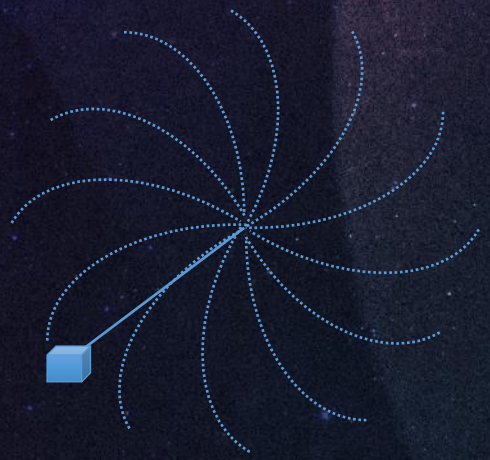
What upgrades might we apply?

- Technology trends to watch:
  - 3D Printing of large structures
  - 3D Printing of sensors and electronics
  - Artificial Intelligence
  - Genetic Programming
  - E-sails and Magnetoshells
  - Spacecraft Miniaturization









FLIGHT HARDWARE UPGRADES @ 4 LY

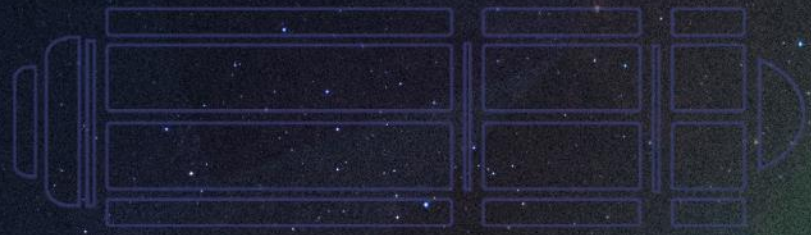
3-D PRINTER

+

MINERAL STOCKS

=

NEW COMPONENTS



FLIGHT HARDWARE UPGRADES @ 4 LY

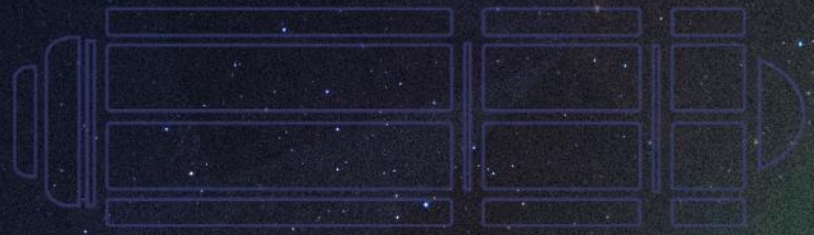
3-D PRINTER

MINERAL STOCKS

NEW COMPONENTS

+

=



FLIGHT HARDWARE UPGRADES @ 4 LY

3-D PRINTER

+

MINERAL STOCKS

=

NEW COMPONENTS

Tap into the creative juices of the entire world through competitions to design upgrades using limited resources

FLIGHT SYSTEM UPGRADES @ 4 LY

3-D PRINTER

+

MINERAL STOCKS

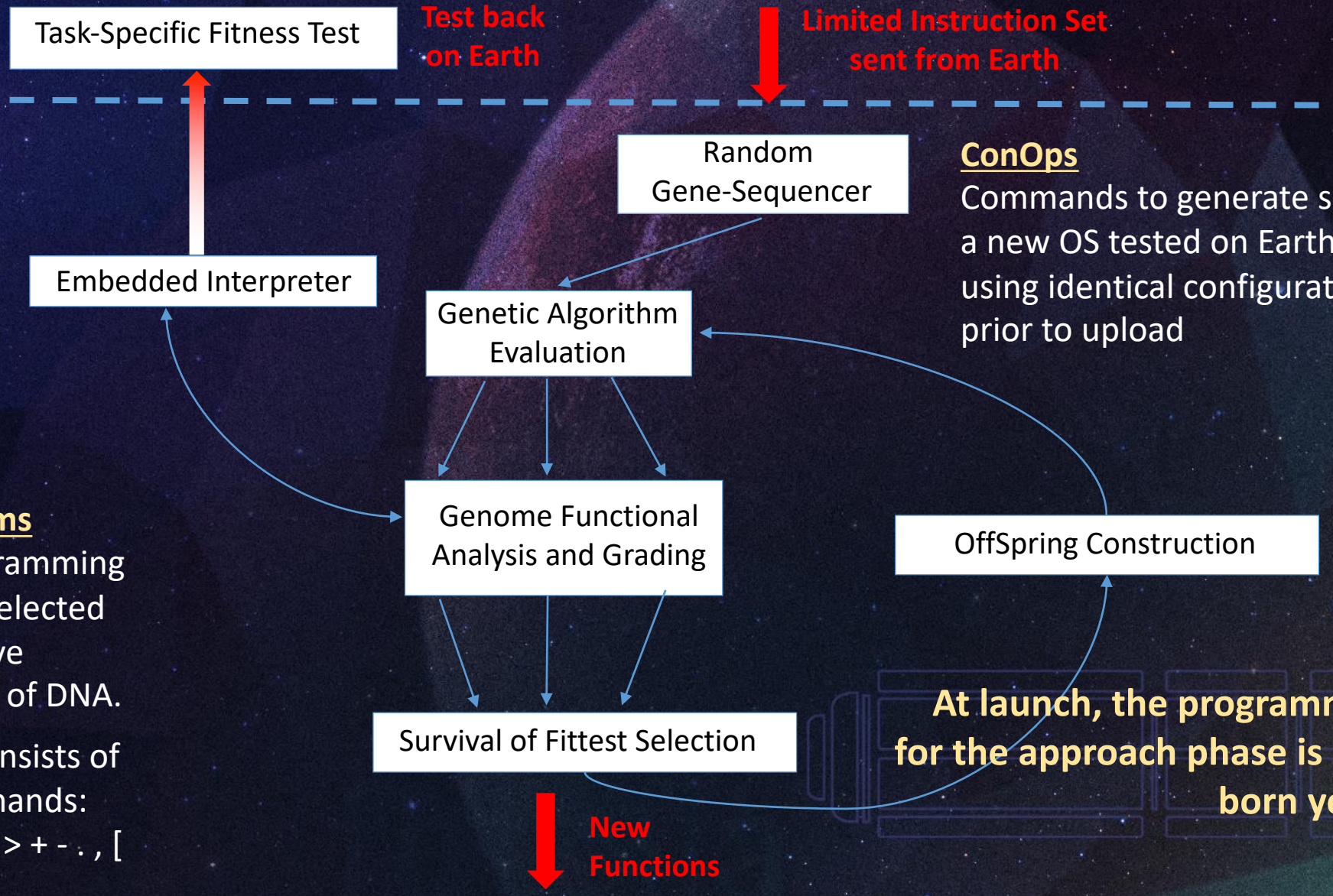
=

NEW COMPONENTS

SOFTWARE

FLIGHT SOFTWARE UPGRADES @ 4 LY?

AI Programming
- uses genetic algorithms coupled with a tightly constrained programming language that minimizes the overhead of its Machine Learning search space.



ConOps
Commands to generate say a new OS tested on Earth using identical configuration prior to upload

Genetic Algorithms
- A series of programming instructions are selected at random to serve as an initial chain of DNA.

Instruction set consists of just 8 basic commands:

< > + - . , [ ]

At launch, the programmer for the approach phase is not born yet…

Acknowledgment: Becker, K., and Gottschlich, J., AI Programmer: Autonomously Creating Software Programs Using Genetic Algorithms, arXiv:1709.05703, arXiv.org (2017)

FINAL THOUGHTS

- In 2011, interplanetary cubesats were considered a wild idea
- In 2018, JPL's two MarCO cubesats are currently en route to Mars…